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VI. *Result of Calculations of the Observations made at various Places of the Eclipse of the Sun, which happened on June 3, 1788. By the Rev. Joseph Piazzi, C. R. Professor of Astronomy in the University of Palermo; communicated by Nevil Maskelyne, D. D. F. R. S. and Astronomer Royal.*

Read January 15, 1789.

TO DR. MASKELYNE.

SIR,

THE satisfaction I had in observing the eclipse of the sun on the third of June last, with you and M. D'ARQUIER, at Greenwich, induces me to give you an account of the use made of the observations, and the consequences I have drawn from them. The observations which I have collected concerning the same eclipse, and which were made in other places, contribute to the extensiveness of my calculations, and to determine the position of certain places, which had not been before accurately determined, as that of Dublin, that of Mitau in Courland, and Perinaldo in Italy. The longitudes of all the other places must be referred to that of the Royal Observatory at Greenwich, as being the first in Europe, and because the observations which you have made in it, are by far more accurate than any others made elsewhere.

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The result of the observation at Greenwich is confirmed in the most satisfactory manner by the observations of Oxford and Loampit-Hill, which Dr. HORNSBY and Mr. AUBERT have done me the honour to communicate to me. These three observations perfectly agree in the latitude of the moon; whence it follows, that the duration of the eclipse was justly observed. And whereas the difference of longitude for Oxford, as determined by these observations, is only one second, and that of Loampit-Hill only two seconds, different from that which had been determined by means of the best time-keepers and other most exact observations, it follows, that these three observations may be considered as a single one, having a treble degree of accuracy. In effect, if the moment of conjunction found for Oxford and Loampit-Hill be reduced to the meridian of Greenwich, by adding to the latter  $5''\cdot4$ , and to the former  $5' 0''$ , and a mean be taken, it will appear, that this mean differs only by  $0\cdot6$  of a second from the conjunction deduced from the observation made at Greenwich only. This also clearly proves, that the eclipses of the sun, when accurately observed, give nearly the same exactness as the occultations of the stars, which from their nature are considered as the most exact.

The observation made at Dublin deserves our greatest attention, particularly since the establishment of a very excellent observatory there. Dr. USSHER confesses, that the longitude of that city has not been exactly determined (see the Transactions of the Royal Irish Academy for the year 1787, p. 86.). He supposes the longitude of Dublin to be  $24' 58''$  W. which he determined by means of a time-keeper, which Mr. ARNOLD happened to take with him to that city; whereas I find it to be  $25' 13''\cdot4$ . This my determination I believe not to leave the uncertainty of two seconds;

seconds, because the latitude of the moon deduced from the observation is the same with that of Greenwich.

The observation of Mitau is likewise very interesting; it shews the situation of a distant country, where no observation had been made before M. BEITLER established an observatory there. The observation of this able astronomer is of such correctness, that it furnishes the same latitude of the moon as the preceding ones; consequently the difference of the meridians, which I thence deduce, may be considered to be as exact as that of Dublin. The difference is 1 h. 34' 54'' E, which becomes of the greater importance to geography, because from Pomerania to Peterburg no one point had been accurately determined before.

The position of Berlin has been already determined by means of some eclipses; but the results do not agree. The difference of 53' 32'', which I have deduced, not only agrees exactly with that mentioned in Vol. IV. of M. DE LA LANDE's *Astronomy*, and which this famous astronomer had deduced from the occultation of Antares observed by himself in the year 1749; but it also comes so near to the longitude mentioned by Mess. LEXELL and BERNOULLI, in the *Ephemeris* of Berlin, as not to differ by more than two seconds.

The observation of Vienna gives for the difference of the meridians 1 h. 5' 31''. Though this determination differs but 1'' from that found in the *Almanack* of Milan, and in the *Requisite Tables*, yet the observations of the two phases had not been very accurately made.

Perinaldo in Italy is a place whose position has not been as yet well determined. The tables requisite for the *Nautical Ephemeris* lay down this place at 30' 40'' to the East of Greenwich; some place it at 30' 20''. The observation made by

M. MARALDI, nephew of the Paris Academician, which I have by me, gives  $30' 53''$  E. for the difference of the meridians, and this may be considered as the best hitherto known.

The observations made at Milan, by the astronomers DE CESARIS and REGGIO, were interrupted by intervening clouds. In fact, the latitude of the moon in conjunction comes out only equal to  $14' 32''$ , which shews that the duration of the eclipse was not properly observed. I have thence also calculated the conjunction separately for the beginning and for the end of the eclipse, and I have found out the following differences of meridians, *viz.* for the beginning  $36' 39''$ ,<sup>6</sup>, and for the end  $36' 38''$ ; and for the end and beginning conjointly  $36' 37''$ . This last difference comes nearest to that mentioned in the Milan Ephemeris for the year 1789, which is  $36' 41''$ . The observation made at Bologna assigns  $45' 28''$  E. for the difference of the meridians. But the duration of the eclipse was not properly observed. However, notwithstanding this imperfection, it may happen that the result determined is exact.

The two observations of France, *viz.* that of Viviers, and that of Rouen, give almost the same difference which I find in the Requisite Tables; that of Rouen differing only  $1''$ , and that of Viviers  $2''$ . As the difference of the meridians between Paris and Rouen is known with the greatest precision to be  $4' 57''$  to the W. of Paris; if to this difference are added  $4' 22''$ ,<sup>3</sup>, which is the difference I found between Rouen and Greenwich, there will result, for the difference of the meridians between the Observatory of Greenwich and Paris,  $9' 19''$ ,<sup>3</sup>. This difference only differs by  $0''$ ,<sup>7</sup> from that established by Dr. BRADLEY, which is  $9' 20''$ , as adopted by yourself, and lately confirmed by Major-general ROY.

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The observations of Loampit-Hill, Greenwich, and Oxford, as they serve for the basis of all my calculations, I have calculated them two different ways, *viz.* by the method of parallactic angles, and by the method of the nonagesimal, and the results agreed together within a few tenths of a second. By these two different methods I have also calculated the observations of Vienna, Berlin, and Viviers, in order to shew, that the different latitudes of the moon, given by the various observations, were not owing to any error in my calculations. For these places, in which both the beginning and the end of the eclipse had been observed, I have deduced the time of conjunction from the two phases conjointly, which have also given the duration of the eclipse, which cannot be obtained from a single observation.

The error of the tables which results from the observation at Greenwich is  $+26''$  in longitude, and  $+11'',5$  in latitude, at 20 h.  $58' 47'',3$  of apparent time, taking for the longitude of the sun  $2s. 14^{\circ} 16' 54'',7$ , as I deduce from the Nautical Almanack, and that of the moon at the same time to be greater than the sun by  $26''$ , as deduced from the same Almanack. I suppose also the horary motion of the moon in the ecliptic, by taking it an half hour before and after the conjunction, to be  $36' 52'' + 0'',6$  for the hour following the conjunction, and  $-0'',6$  for the hour preceding the conjunction; the moon's horary motion in latitude is  $3' 24'',3$ ; the horizontal parallax of the moon *minus* that of the sun at Greenwich, to be  $60' 14'',4$  for the commencement of the eclipse, and  $60' 16'',4$  for the end; the sun's diameter  $31' 34'',6$ , less by  $3''$  than that given in the Almanack, according to the correction which you have found necessary to be made; the moon's diameter I have stated as in the Almanack. In the opinion of M. DE LA LANDE,

some correction ought to be made to the parallax and to the diameter of the moon, as well as to the diameter of the sun; but on the one hand this would not make any alteration in the difference of the meridians which I have found; and on the other I thought proper to make use of those elements the Nautical Almanack furnished me with, that being a work the most perfect of the kind that ever appeared, and to which all astronomers and navigators ought to pay the greatest attention.

In fine, I compared the moon's longitude in conjunction deduced from the eclipse with the new tables of the moon corrected by Mr. MASON, and found the longitude by those tables to be 2 s.  $14^{\circ} 17' 6''$ ,4, and the latitude to be  $15' 1''$ ,3. The error then of the new Tables is  $+11''$ ,7 in longitude, and  $+13''$ ,1 in latitude; but M. DE LA LANDE having lately sent to me from Paris the place of the sun, calculated with the new Solar Tables (a most useful improvement which M. DE LAMBRE has, with much ingenuity, deduced from your observations) I find the error in longitude to be  $+27''$ ,4, the sun's place being 2 s.  $14^{\circ} 16' 39''$ ,0 at 20 h.  $58' 47''$ ,3.

The following table contains the observations of the eclipse, and the results deduced from thence. The first vertical column shews the name and place of the observers; the two next vertical columns contain all those observations which have been made, in apparent time; the other columns shew the results, *viz.* the fourth column, contains the true conjunction in apparent time; the fifth column contains the longitude of the moon in conjunction, which being always the same, needs not to be repeated under every perpendicular column; the sixth column contains the latitude of the moon, which, as it depends upon the manner of observing the two phases, is subject to

some variety ; the seventh or last column contains the difference between the various meridians and that of Greenwich.

This, Sir, in brief, is the result which I have been able to deduce from the various observations above mentioned, and which I intirely submit to your judgement. If you think that it deserves to be made public, and in that case would be pleased to present this Paper to the Royal Society, I shall esteem myself extremely honoured and obliged by it.

I have the honour to be, &c.

JOSEPH PIAZZI.



*Mr. PIAZZI's Calculations of Longitudes*

Table of the observations made at various places on the eclipse of the sun, which happened June 3, 1788, and of results deduced from the same.

	Beginning.	End.	Conjunction.	Longitude of the moon in conjunction.	Latitude in conjunction.	Difference of meridians.
Greenwich, Dr. MASKE- LYNE.	h. 19 24 46,5	h. 21 1 24,0	h. 20 58 47,3		14 48,2	0
Loampit- Hill, Mr. AUBERT.	19 24 41,9	21 1 20,3	20 58 44,1		14 48,2	3,2W
Oxford, Dr. HORNSBY.	19 20 36,1	20 54 40,0	20 53 46,2		14 48,7	5 1,1W
Dublin, Dr. USSHER.	19 5 46,5	20 27 42,1	20 33 33,9		14 48,3	25 13,4W
Mittau, M. BEITLER.	21 20 15,0	23 8 52,0	22 33 41,5		14 48,7	h. 1 34 54,2E
Berlin, M. BODE.	20 23 9,0	22 14 32,0	21 52 20,3		14 44,2	0 53 33E
Vienna, M. TRIES- NEKER.	20 25 49,0	22 32 40,0	22 4 18,8	S. 2 14 16 54,7	14 39,0	1 5 31,5E
Viviers, M. FLAU- GERGUAS.	19 26 38,0	21 25 41,0	21 17 29,0		14 33,0	18 41,7E
Perinaldo, M. MARALDI.	19 37 50,0	*	21 29 40		*	30 53,0E
Rouen, M. DU LAGNE.	*	21 7 15,0	21 3 9,6		*	4 22,3E
Milan, Mess. DE CESARIS and REGGIO.	19 48 23,0	21 51 14,0	21 35 24,7		14 32,0	36 37,4E
Bologna, M. MATTEUCCI.	19 55 10,5	22 3 45,5	21 44 15,3		14 31,0	45 28E
Padua, M. CHIMI- NELLO.	19 59 20,0	22 6 58,0	21 46 21,3		14 39,0	47 34E

P O S T S C R I P T.

IN the month of February last, I was favoured by Count DE BRUHL with the observation of the eclipse of the 4th of June last, made at Warsaw by M. BYSTRZYSKI; about the same time I also received of M. DE LA LANDE some other observations of the same eclipse, *viz.* those made at Prague, Marseilles, Crefmunster, and Bagdad in Mesopotamia, which I immediately calculated, in order to add them to the others, which Dr. MASKELYNE lately did me the honour of presenting to the Royal Society.

The observation of Marseilles confirms in the best manner the difference of meridians set down in the *Requisite Tables*, differing from that only by a second. The observation of Warsaw gives a difference ten seconds greater, and that of Crefmunster fourteen seconds less; which differences ought not to surprize us, considering the observations upon which the longitudes of these two places had been established; but, on the other hand, the observation of Prague clearly proves, that the situation of that town had been much less accurately determined than one might have expected. The time for the conjunction, which results from this observation, is the very same as that which is deduced by M. GERSTNER's new method, described in the Berlin Ephemeris for the year 1791, p. 243. From this time of conjunction the difference of meridians comes out equal to  $57^{\circ} 42''{,}7$ , *viz.* one minute and seventeen seconds less than that of the *Requisite Tables*.

The calculation of the observation made at Bagdat seems to indicate that there is some mistake with regard to the end of the eclipse, having found, that the difference of apparent longitude

gitude at the end is  $20''$  greater than the sum of the semi-diameters of the sun and moon, increased in proportion of the apparent altitude of the moon : for this reason I do not give the moon's latitude in conjunction. As for the time of the conjunction, I deduce it both from the two phases together, and from the commencement only, having previously corrected the moon's latitude of the error which I discovered in the tables, *viz.*  $11'',6$ . The time of conjunction which results from the first calculation is  $23\text{ h. }56' 11''$ ; that which results from the second  $23\text{ h. }56' 16''$ : this last nearly agrees in the difference of meridians with the Ephemeris of Paris for the year 1789, and differs from the Requisite Tables by  $2' 32''$ .

The following table represents, as the first, the observations and the results.

	Beginning.	End.	Conjunction.	Longitude.	Latitude.	Difference of meridians.
Warsaw, M. BYSTRZYSKI	h. $20\ 56\ 45$	h. $22\ 57\ 33$	h. $22\ 22\ 59,3$		$14\ 44'$	h. $1\ 24\ 12$
Prague, M. STERNADT.	$20\ 21\ 29$	$22\ 21\ 15$	$21\ 56\ 30$		$14\ 45'$	$0\ 57\ 42,7$
Marseilles, M. BERNARD.	$19\ 26\ 42$	$21\ 29\ 23,5$	$21\ 20\ 17,5$		$14\ 40'$	$0\ 21\ 30,2$
Crefmunster, M. FIXL- MILLNER.	$20\ 15\ 20$	$22\ 19\ 50,7$	$21\ 54\ 59$		$14\ 23'$	$0\ 56\ 11,7$
Bagdad, M. DE BEAU- CHAMP.	$22\ 30\ 51$	$23\ 26\ 19$	$23\ 56\ 11$		*	$2\ 57\ 23,7$

